RELATIONSHIPS BETWEEN MICROARTHROPOD COMMUNITIES AND SOIL AND VEGETATIONAL TYPES

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SYNOPSIS

Published data on the occurrence and dominance of acarine and collembolan species in northern European grassland sites were subjected to principal coordinate analysis in order to determine whether a relationship could be detected between faunal composition and site characteristics.

The resulting site ordination with regard to the principal axes indicates broad relationships between acarine communities and soil types. Soil organic matter content, moisture content and base status appeared to be factors of significance in determining the relationships, but site vegetation did not appear to be important in this regard.

No obvious relationships could be detected between collembolan communities and soil and vegetational types.

INTRODUCTION

Soil microarthropods are predominantly associated with the organic matter system; they are particularly abundant in soils of high organic matter where water content is not limiting and high populations are commonly found associated with organic residues added to soil. Attempts to correlate their occurrence with soil and vegetational characteristics have been made by various authors with varying degrees of success: Weis-Fogh (1948) succeeded in relating changes in microarthropod community structure to vegetational and moisture gradients along a transect on a sandy Danish plain; Wood (1967b) recognised various micro-arthropod communities in moorland sites but these were not obviously related to botanical features. Curry (1973) detected qualitative effects of litter type on community structure, but Curry & Ganley (1977) found little qualitative difference in the microarthropod communities associated with corresponding root types. Faunal density, however, did appear to be affected by root type. Likewise, Macfadyen (1952) found acarine and collembolan density to be affected by plant identity in a fen soil, but no effects of plant species on arthropod species composition were apparent. Evidence for close association between arthropod and plant species in poorer soils is available for blanket bog (Blackith 1974) and steppe (Stebaeva 1963).

A number of biocoenological studies of soil microarthropods have been carried out in Europe with the aims of describing, delimiting and classifying invertebrate communities associated with vegetational and soil types. The studies of Strenzke (1952) and Knulle (1957) are particularly noteworthy; they established various acarine synusiae associated with various plant associations on the North German coastal plain. Likewise, Dunger (1975) delimited edaphic synusiae coresponding to vegetational types along a valley slope near Jena.

The approach adopted in the present study is a corollary of the biocoenological approach, namely, an attempt to classify grassland sites representing various vegetational and soil types on the basis of their microarthropod faunas.

METHODS

Forty-three European sites were chosen, representing a variety of grassland types for which fairly complete records of acarine and collembolan species occurrence and abundance were available (Table 1). A few non-grassland sites were included for purposes of comparison. The ordination technique used was that of principal coordinate analysis (Gower 1966), using the computer programme PCOORD as described by Blackith & Reyment (1971). This technique has been applied to a wide range of classificatory problems in systematics and ecology (Blackith & Reyment 1971, Blackith & Blackith 1975, Curry & Ganley 1977). The input data were numerical dominance values scored on a scale of 0-9 for the 120 species of Acari and 50 species of Collembola which occurred with relative abundance of 2% or greater in any of the sites under consideration. The data represented means of several samplings at different seasons of the year in most cases. The programme was run first with combined acarine and collembolan data for the thirty-five sites for which data on those two groups were available; then with acarine data alone for thirty-nine sites, and finally with collembolan data only for forty sites.

The programme extracts a number of axes of variation corresponding to the eigenvectors of the association matrix generated from the data, and ordinates the sites with respect to these. Soil and vegetation types are represented in the Figs. by the abbreviations and symbols indicated in Table 2.

RESULTS

Site ordination with respect to Axes 1 and 2 is shown in Figs. 1 to 3. There appears to be a marked segregation of sites with respect to Axis 1 into three broad categories in Fig. 1: lowland sandy soils on the right, lowland loams and clay soils in the centre, and acid hill and moorland soils on the left. Fen soils appear to have a greater affinity for lowland mineral soils than they do for the more organic moorland soils. When considering what site parameter(s) Axis 1 represents, organic matter content immediately comes to mind: the soils on the right are largely mineral soils of low organic matter content, those on the left are either peat soils or mineral soils with well developed surface organic layers. Clearly organic matter is not the only factor

Table 1. The sites included in the analysis.

Moorland

1. Moor House limestone grassland (Block 1965, Hale 1966).
2. " *Calluna*
3. " *Juncus*
4. " *Nardus*
5. Malham Tarn Site S (Wood 1967)
6. " " " III "
7. " " P "
8. " " IV "
9. " " V "
10. " " VI "
11. Glenamoy virgin bog (Blackith 1974, Longworth 1973).
12. " shelter belt
13. " reclaimed bog
14. Lullymore old grassland (Whelan 1976)

Fen

15. Cothill *Molinia* (Macfadyen 1952)
16. " *Deschampsia* " "
17. " *Juncus* " "
18. Spikbole (Persson & Lohm 1977)
19. Lullymore 2nd year ley (Whelan 1976)
20. " 4th " " " "
21. Hardangervidda dry eutrophic meadow (Kauri 1973)
22. " wet eutrophic meadow " "

Hill Pasture

23. Lyons Hill (Curry 1969).
24. Stepaside (Valarasan 1971).

Heathland

25. Ivantjärnsheden pine stand (Persson 1975)
26. Hardangervidda lichen heath (Kauri 1973)

Lowland grassland loam and clay soils

27. Glasnevin (Ganley 1976)
28. Corby (Davis 1963)
29. Headley Hall (Dhillon & Gibson 1962)
30. Park Grass (Edwards & Lofty 1975)
31. Spinney Pasture (Salt, Hollick, Raw & Brian, 1948).
32. Bellahouston Park (Sheals 1957).

Lowland grassland sandy soils

33. Danish raised beach Site I (Weis-Fogh 1948)
34. " " " " II " "
35. " " " " III " "
36. " " " " IV " "
37. " " " " V " "
38. " " " " VII " "
39. Hermitage Plain south side ant mound (Haarløv 1960)
40. " north side " " " "
41. " level pasture " "
42. " hawthorn thicket " "
43. " pond shore " "

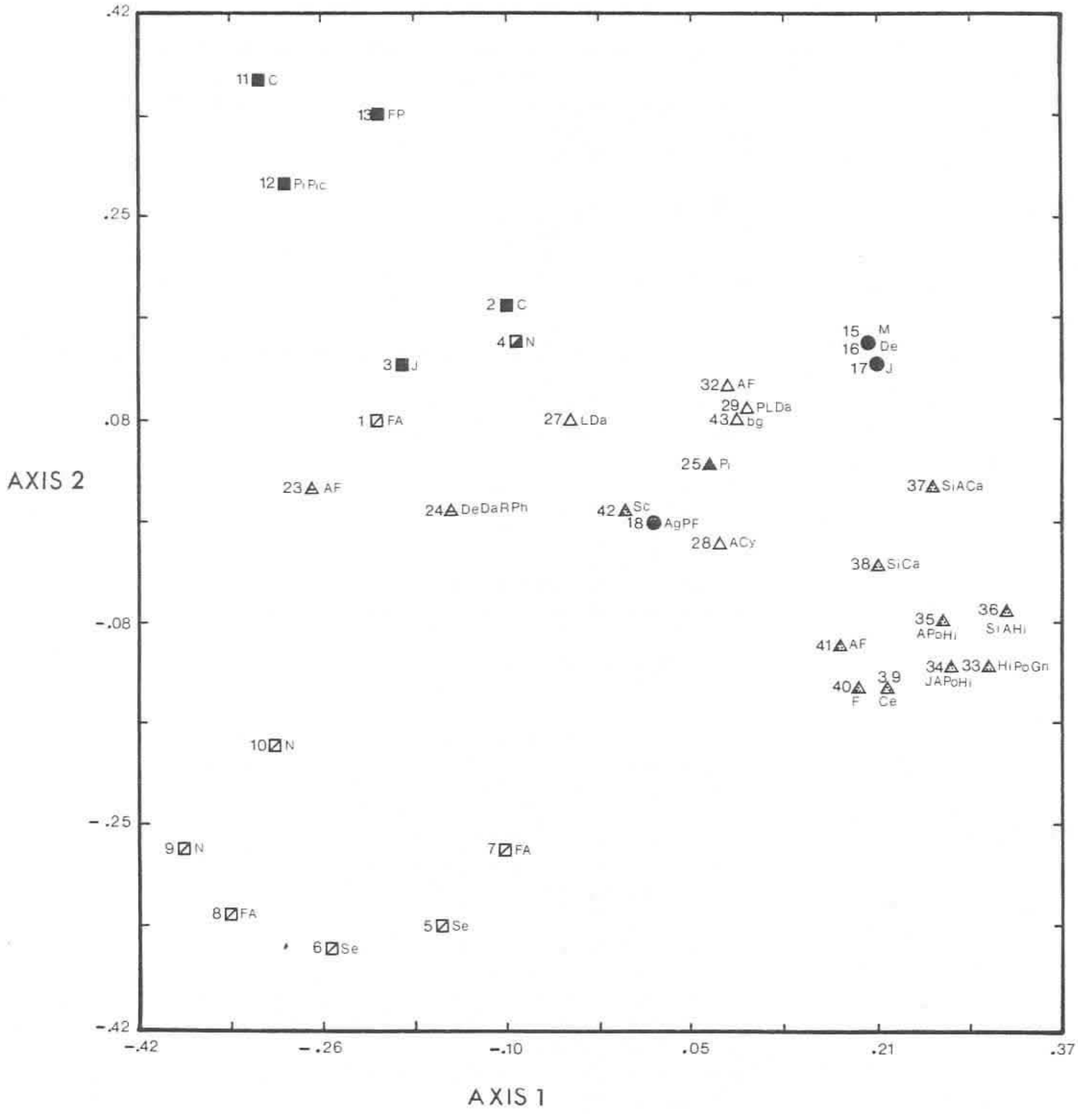

Fig. 1. Ordination of thirty-five European sites on the basis of their soil acarine and collembolan fauna.

involved, as evidenced by the positions of the fen soils. A feature which may account for their affinity with clay soils is their base richness: the other organic sites, and particularly the blanket peat sites, are acidic and poor in bases.

Axis 2 appears to represent factors associated with moisture content in Fig. 1. This can be deduced from the positions of sites 33 to 38 which were located along a gradient of increasing soil moisture content and also from the positions of the water-logged blanket bog soils on the chart. Axis 1 does not, however, represent a simple moisture gradient: Malham Tarn is a high rainfall area with precipitation in excess of 1400 mm spread over more than 200 days per annum and, on this basis, the position of sites 5 to 10 at the "dry" end of the range appears anomalous.

Fig. 1 offers little evidence that vegetation per se is a factor of significance in determining microarthropod distribution: sites 25, 43 and 29, for instance, are quite dissimilar in regard to vegetation, but are nevertheless located adjacent to one another on the chart.

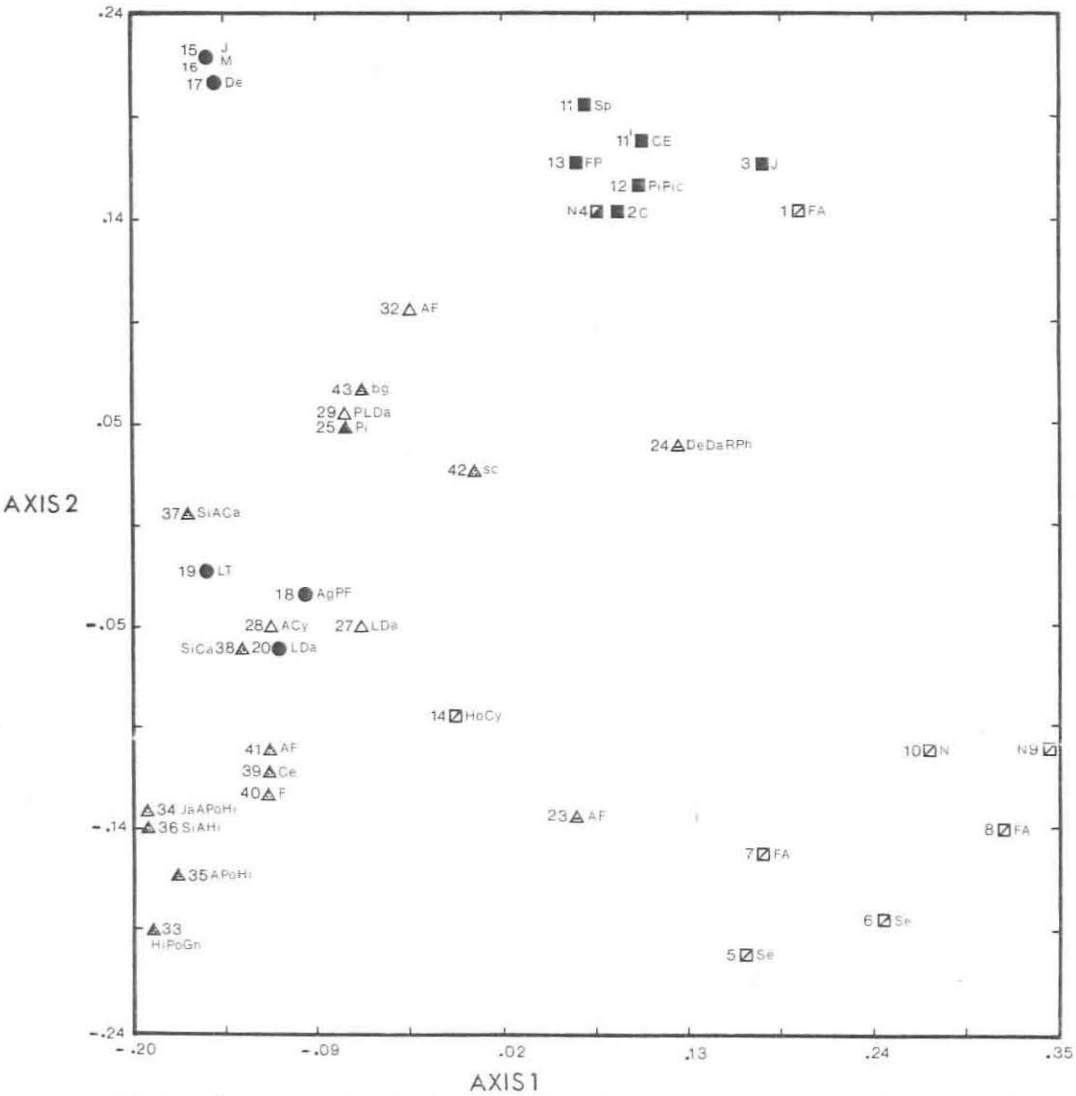

Fig. 2. Ordination of thirty-nine European sites on the basis of their soil acarine fauna.

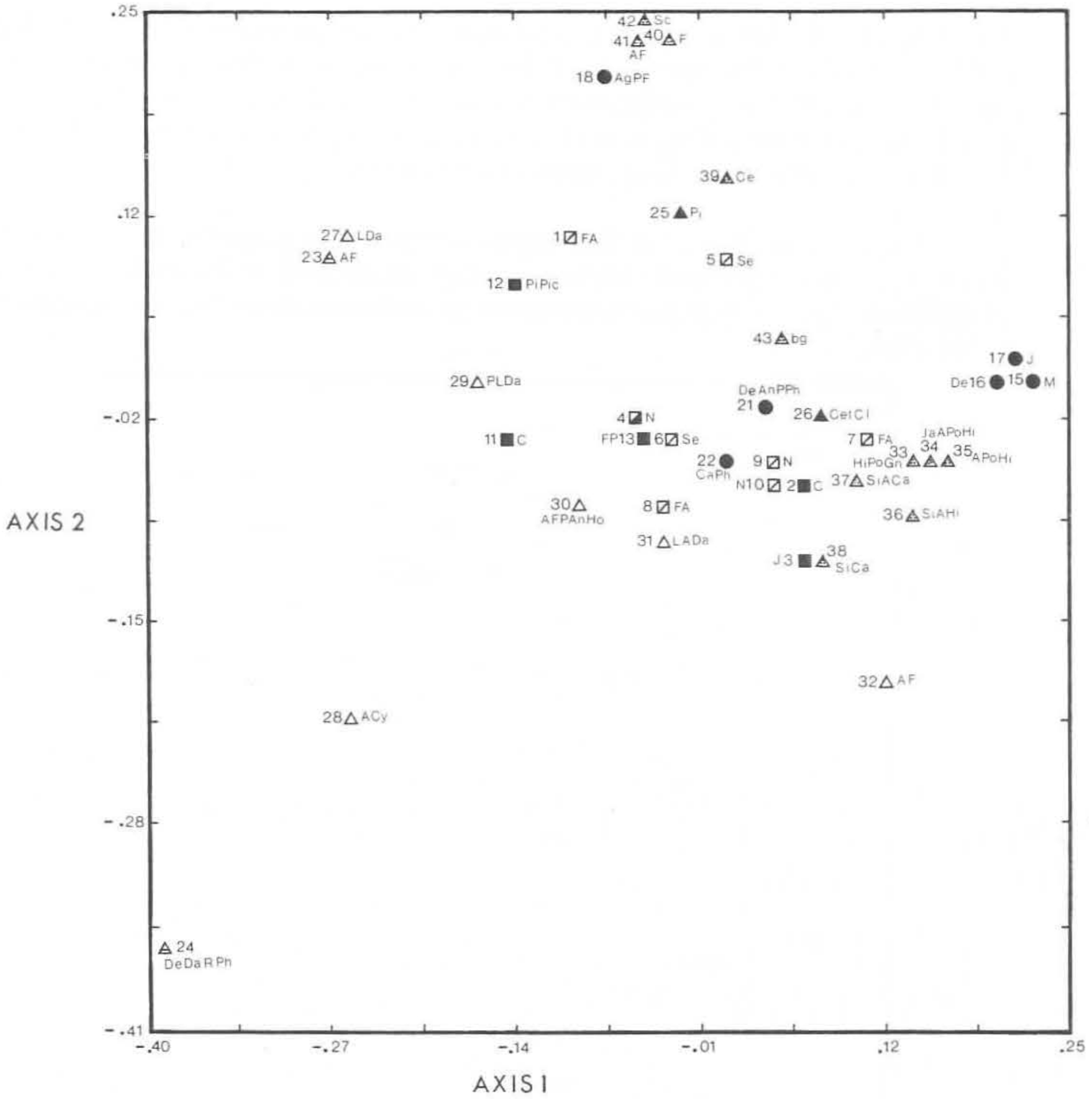

Fig. 3. Ordination of forty European sites on the basis of their soil collembolan fauna.

Geographical propinquity is clearly an important factor influencing site ordination in this study, with the sites of greatest affinity in many cases being those located in closest proximity to one another.

Examination of Figs. 2 and 3 indicates that it is the acarine component of microarthropod communities rather than the collembolan which is most influenced by soil type. An interesting feature of Fig. 2 is the high degree of affinity between the blanket peat sites of Moor House and Glenamoy.

Table 2. Key to symbols and abbreviations used in Figs. 1-3.

Vegetation

A	*Agrostis* (Gramineae)	J	*Juncus* (Juncaceae)
Ag	*Agropyron* (Gramineae)	Ja	*Jasione* (Campanulaceae)
An	*Anthoxanthum* (Gramineae)	L	*lolium* (Gramineae)
bg	bare ground	M	*Molinia* (Gramineae)
C	*Calluna* (Ericaceae)	N	*Nardus* (Gramineae)
Ca	*Carex* (Cyperaceae)	P	*Poa* (Gramineae)
Ce	*Ceratodon* (bryophyte)	Ph	*Phleum* (Gramineae)
Cet	*Cetraria* (lichen)	Pi	*Pinus* (Coniferae)
Cl	*Cladonia* (lichen)	Pic	*Picea* (Coniferae)
Cy	*Cynosurus* (Gramineae)	Po	*Polytrichum* (bryophyte)
Da	*Dactylis* (Gramineae)	R	*Rubus* (Rosaceae)
De	*Deschampsia* (Gramineae)	sc	scrub
E	*Erica* (Ericaceae)	Se	*Sesleria* (Gramineae)
F	*Festuca* (Gramineae)	Si	*Sieglingia* (Gramineae)
Gn	*Gnaphalium* (Compositae)	Sp	*Sphagnum* (bryophyte)
Hi	*Hieracium* (Compositae)	T	*Trifolium* (Papilionaceae)
Ho	*Holcus* (Gramineae)		

Soil

■	Moorland – peat	◭	Hill grassland
⧄	Moorland–mineral	△	Lowland loam to heavy clay
◪	Moorland – peat and mineral mixed alluvium	◬	Lowland sandy to silty loam
●	Fen	▲	Heath

DISCUSSION

It has been contended that a knowledge of the microarthropod communities associated with particular soil and vegetation types might provide a useful biological basis for soil classification, and that changes in community structure might be useful in detecting deleterious effects of management practises on soil fertility. Generally speaking, however, systems of community delimitation developed in particular regions have not proved applicable in comparable habitats elsewhere and, for this reason, their indicative value has been limited.

The present study indicates that broad relationships between microarthropod communities and soil types can be detected using the technique of principal coordinate analysis. Admittedly the sites chosen represent strongly contrasting soil types; it remains to be seen whether useful results can be achieved in less extreme cases. Clearly acarine community structure is more affected by soil type than is collembolan, suggesting that the more abundant soil collembolan species are eurytopic, with wide ecological valence, whereas acarine species by contrast tend to be abundant in a more restricted range of habitats. It is interesting to note that Blackith & Blackith (1975) achieved quite different results for European sites ordinated on the basis of their total collembolan species lists; it appears therefore that distribution patterns of scarce collembolan species may be more affected by soil type than are patterns of numerical dominance of abundant species.

The presence of so many eurytopic species in the sites considered is interesting in relation to current thinking on niche breadth (May 1973, Pianka 1976) which might lead one to expect a high degree of resource specialisation (niche narrowness) in the buffered environments of temperate grassland soils. Clearly, species packing in the soil context is not a simple function of competition for food, since many soil arthropod species which appear to be remarkably general in feeding habits are able to coexist. This is not to say that food is never a limiting factor for soil arthropods, but it does suggest that interspecific competition for food is being kept at a low level. Factors which may be significant in reducing competition include soil microstructure (Haarløv 1960, Anderson 1971), aggregation behaviour (Usher 1976), and probably also predation (Harris & Usher 1977), and physical and chemical gradients in the soil, although the role of these factors is as yet poorly understood.

The apparent absence of relationships between vegetation type and microarthropod community structure conforms to the general experience for grassland soils: it is noteworthy that the best examples of plant-soil-microarthropod associations come from impoverished soils such as blanket bog and steppe where biological activity tends to be restricted to the vicinity of plant root systems. Blackith (1974) considers that in such situations soil animals are forced to live in close association with plants and are more subject to the selective influences of their rhizospheres.

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